THE INTERNATIONAL COMMITTEE ON AERONAUTICS.

In connection with the report of the proceedings of the recent Meteorological Conference at Paris (see October REVIEW, pages 365–367), Mr. A. Lawrence Rotch desires us to say that the Aeronautical Committee appointed by the International Meteorological Committee, consisted of Messrs. Assmann, Erk, de Fonvielle, Hergesell, Hermite, Pomortzeff, and Rotch, and has recently been enlarged by the addition of Messrs. Andrée, Berson, Cailletet, and Jaubert. M. Hergesell has been named President, and M. de Fonvielle, Secretary.

CONSTANTS AND UNITS USED IN METEOROLOGY.

During the past two centuries the progress of the physical sciences, and especially meteorology, has been appreciably hindered by the wide-spread diversity of usage as to the units or standards of measurement. Each nation and sovereign, and even the smallest states, as also different classes of merchants and artisans, have, from time to time, introduced new standards; many of those in use date back to unknown epochs in the history of civilization. During the past fifty years a strong effort has been made, with steadily increasing success, to facilitate our progress by the rejection of minor units and by the general adoption of the metric system. At the present time meteorology is the only branch of science which has officially recognized the fact that absolute uniformity of usage is not at present attainable, but that the choice may at least be restricted to either the metric or the English system. A vote to this effect was taken at the International Meteorological Conference in Rome in 1879; since that date the meteorological world has awaited with great interest the results of the authoritative comparisons between the English and metric standards that have been undertaken by the International Bureau of Weights and Measures. This latter bureau has its laboratories and workshops at Sevres (Pavillon de Breteuil), near Paris, and its expenses are defrayed by many nations, each of which bears its own proper proportion. Pending the final conclusions of this important international bureau the meteorologists assembled in their successive international conferences have adopted and recommended the tables prepared by their own committee, Messrs. E. Mascart and H. Wild, which were published in 1890 in a large quarto volume. Since that date these tables have undoubtedly been accepted everywhere as the authoritative standard for the use of meteorologists. In two respects only (the hygrometric tables and those for the reduction of the barometer to sea level) do the distinguished authors state that serious difficulties were experienced in their efforts to realize a high degree of accuracy and authoritative uniformity.

Although these international tables must for some time to come continue to be our authority, yet the time will undoubtedly arrive when a new edition will be authorized by the permanent meteorological committee or the International Congress, which it represents. It will, therefore, be of interest to consider the present state of our knowledge of the values of the units and constants that are important to meteorology and the relation of the English and metric systems of measurement.

(1.) With regard to thermometry, which is a fundamental consideration in all measurements, the International Bureau has definitely abandoned the mercurial thermometer, considered as a normal, and has adopted instead the hydrogen thermometer. With this normal any mercurial may be compared, so that by using a special method of manipulation and a proper system of corrections we may deduce normal temperatures from mercurial thermometers. It has been the practice of the United States Weather Bureau since 1881 to use the air-glass thermometer and await a final determination of the small outstanding reductions to the normal scale of the International Bureau.

(2.) With regard to the ratio between the meter and the yard a recent report (September, 1896) by the president of the International Bureau calls attention to the fact that, in order that there may be no doubt about the temperature (62° F.) at which the imperial standard yard preserved at London has its legal standard length, the bureau assumes that this is measured, not on the normal mercurial thermometer, as heretofore, but on the normal scale adopted by that bureau. Under this assumption, it follows that the relation between the normal lengths of these two standards is such that one yard equals 0.91439916 meters. Owing to the many difficulties inherent to this comparison, especially due to the differences in length and temperature of the two normals, the president of the International Bureau states that some doubt may still remain with regard to the last two figures, and he recommends adopting 0.9143992. From this ratio, it follows that one meter is equal to 1.0936143 yards, or 3.2808429 feet, or 39.370113 inches. The provisional value adopted by the International Meteorological Tables is Kater's value, viz: one meter equals 39.37079 inches, or 1.09363306 yards, whence one yard equals 0.91438348 meter. This latter value was also adopted by the United States Weather Bureau in 1875 in reduction tables compiled by the Editor for the preparation of its Bulletin of International Simultaneous Meteorological Observations.

(3.) With regard to the ratio between the pound and the kilogram, a recent edition of the circular and tables of the United States Coast and Geodetic Survey, published in July, 1893, adopts the following: one kilogram equals 15432.35639 grains Troy, or 2.204622627 pounds avoirdupois, whence one pound avoirdupois equals 453.5924277 grams and one grain Troy equals 0.06479891824 gram. In a recent letter to the Editor, Gen. W. W. Duffield, Superintendent of the United States Coast and Geodetic Survey, states that:

> This value for the pound in terms of the kilogram depends upon—
>
> (*A*) Comparisons made at the Standards Office, London, in 1874, between the platinum pound "S" and the Imperial Standard pound, "P. S."
>
> (*B*) The determination of the relation of the pound "S." to the international kilogram made at the International Bureau of Weights and Measures in 1883.
>
> The result of the comparison of the pounds with one another (see Ninth Annual Report of the Warden of the Standards, Appendix IV) gave "S" = "P. S." —0.01664 grain, or "S" = 6999.98336 grains. The value of "S," resulting from the work done at the International Bureau of Weights and Measures (see *Travaux et Memoires*, Tome IV) was "S" equals 453.5913494 grams. The value of "P. S." is, therefore, 453.5913494 grams plus 0.01664 grain or 0.0010783 gram, equals 453.5924277 grams.
>
> After the return of the pound "S" to London from the International Bureau of Weights and Measures, a re-comparison of it with "P. S." was undertaken by Mr. Chaney, Superintendent of Weights and Measures, but the result of this comparison was not used, although it differed slightly from that of 1874.

The value of the ratio of the pound to the kilogram adopted in the International Meteorological Tables was deduced from nearly the same data, by a slightly different combination of measurements, with the following results: one kilogram equals 15432.350 grains Troy, whence one grain Troy equals 0.06479894 gram.

This ratio enters into theoretical meteorology in the value of the weight of a unit volume of air, it would also enter into our every day work if we should adopt the most rational method of expressing atmospheric pressure, viz, in pounds to the square foot or kilograms to the square meter instead of using the apparent barometric pressure without regard to the force of gravity.

(4.) The weight of a liter of pure dry air, containing the average amount of carbonic acid gas, at 0° C., and the pressure of 760 millimeters of mercury, under the force of gravity that prevails at sea level and latitude 45°, was computed by the International Bureau of Weights and Measures at 1.293052 grams, which value is based essentially upon the measurements made by Regnault in the laboratory of the College de France, and this number is adopted in the International Meteorological Tables.

According to Professor Mendeleef, President of the Central Board of Weights and Measures for Russia, the average value arrived at by him is 0.00131844 × gravity, which, using Helmert's value, 980.597, for gravity at 45° and sea level, would give 1.29287 grams; but if we use Putnam's value, 980.630, we get 1.29291, with an uncertainty of 1 in the fourth decimal place (see Nature, March 7, 1895, Vol. LI, p. 452).

(5.) With regard to the force of gravity at any point on the earth's surface no authoritative discussion of the subject for the whole globe has as yet been published, neither by the International Bureau of Weights and Measures nor by the International Geodetic Association. In fact, although nearly a thousand stations have been occupied, yet Helmert, as president of the latter association, states (*Verhandlungen Allgemeinen Conferenz*, 1896) that the time has not yet arrived for a definitive decision, although the errors of the various formulæ, are well recognized. Mr. G. R. Putnam, of the United States Coast and Geodetic Survey states that—

The following formula represents the relative force of gravity, in dynes, at all American stations as far as yet observed, to within $\frac{1}{4000}$ part of g and at all stations except Pikes Peak and similar mountain stations to within $\frac{1}{8000}$:

$$g=978.066\left(1+0.005243\ \sin^2\phi-\frac{2H}{r}-P\right)$$

This formula retains the term $-\frac{2gH}{r}$ which expresses the diminution of gravity due to the elevation (H) above the sea level, by which quantity the distance of the pendulum from the center of the earth has been increased, but it rejects the term $+\frac{2gH}{r}\cdot\frac{3}{4}\frac{\delta}{\Delta}$ introduced by Bouguer to allow for the attraction of the mass of the stratum elevated above sea level, assuming the station to be located on a horizontal plain. The term $-P$ allows for the departure of the local topography from this latter assumption, and requires for its computation a knowledge of the topography of the neighborhood; it is practically inappreciable at most points, its maximum effect at any of the stations occupied within the United States is $\frac{1}{20000}$ of g (at Pikes Peak); it would, necessarily, be omitted in barometric tables. Another correction suggested by Faye, and depending on the relation of the station to the average elevation of the surrounding region, was tentatively employed by Mr. Putnam (Coast and Geodetic Survey, Report 1894, App. I, pp. 25–27), and was found to give a more satisfactory agreement between observed and computed values of gravity. With it the largest discrepancy in the American stations diminished to $\frac{1}{13000}$, and the discrepancy at Pikes Peak almost entirely disappeared. Its application also requires a knowledge of the surrounding topography, and it would necessarily be omitted in barometric tables. The absolute term, 978.066, in the above formula must be considered uncertain by about $\frac{1}{10000}$ part, due to uncertainties in the measurement of the absolute force of gravity; it agrees closely, however, with the mean of the best determinations made throughout the world, and differs by only about the $\frac{1}{35000}$ part at Washington, from the value deduced by Helmert from a general combination of pendulum observations.

Mr. Putnam states, as indeed can be seen from the tabular data given in the above-mentioned memoir, that there is every reason to believe that the simple formula of two terms

$$978.066\left(1+0.005243\ \sin^2\varphi-\frac{2}{r}H\right)$$

or Helmert's formula of 1884 in his Higher Geodesy, Vol. II,

$$g=978.000\left(1+0.005310\ \sin^2\varphi-\frac{2H}{r}\right)$$

omitting the topographic term, will represent the force of gravity at American stations to within $\frac{1}{4000}$ part of its value. Whenever the altitude of a station is determined by accurate leveling, the local force of gravity should be determined at the same time, otherwise we lose the advantage of accuracy of altitude.

As an illustration of the application of all three terms of the above formula the following examples are given:

	Pikes Peak dynes.	Salt Lake City dynes.
Gravity constant	978.066	978.066
Correction for latitude	+ 2.017	+ 2.188
Corrected	980.083	980.254
Correction for altitude	— 1.321	— 0.407
Corrected	978.762	979.847
Correction for topography	— 0.048	— 0.004
Computed local gravity	978.714	979.843
Observed local gravity	978.940	979.789
Observed minus computed	+ 0.226	— 0.054

Instead of $\sin^2\varphi$, the equivalent expression $\frac{1}{2}(1-\cos 2\varphi)$ is frequently preferred. Therefore, for this case, Mr. Putnam's formula may be written

$$980.630\left(1-0.0026146\cos 2\varphi-\frac{2H}{1.0026215\,r}-\frac{P}{1.0026}\right)$$

where the average radius may ordinarily be used for r, in which case the factor of H in meters becomes

$$\frac{2}{1.0026215}\times\frac{1}{6370191}=\frac{1}{3193445}$$

similarly Helmert's formula becomes

$$980.597\left(1-0.002648\cos 2\varphi-\frac{2H}{1.002655\,r}\right)$$

The value of gravity as given in the International Meteorological Tables, is computed by the formula adopted by Broch for the use of the International Bureau of Weights and Measures; it retains the term introduced by Bouguer, but assumes that the density of the elevated plateau is one-half that of the earth, whence the expression $\frac{2gH}{r}\left(1-\frac{3}{4}\cdot\frac{\delta}{\Delta}\right)$ becomes $\frac{2gH}{r}\left(1-\frac{3}{8}\right)=\frac{5}{4}\cdot\frac{gH}{r}$, so that Broch's final formula, when H is given in meters, reads—

$$g=g_{45}\left(1-0.00259\cos 2\varphi\right)\left(1-\frac{5}{4}\cdot\frac{H}{6370000}\right)$$

This expression for gravity appears in the geodetic section (p. A 13), and again, of course, in the barometric section (p. A 33 and A 35) of the international tables. It is evident that such computed values of gravity do not always possess the accuracy that is desired in barometric work, and that it will be best, whenever possible, to determine the value by direct observation which can easily be done by the improved methods of the United States Coast and Geodetic Survey.

The further diminution of gravity, with ascent into the atmosphere above the earth's surface, follows the simple law of the inverse square of the distance from the earth's center and its effect upon the weight of the air above us, and, therefore, upon our barometric observations, can easily be determined. In order to compute the value of gravity at the height z above the station, whose elevation is H, it suffices to add another factor $\left(1-\frac{2z}{r+H}\right)$ to either of the above formulæ.

(6.) With regard to the radius of the earth, Mr. O. H. Tittmann states that the Coast and Geodetic Survey has for many years used the so-called Clarke's spheroid, as best adapted to the development of its existing triangulation, but in the present state of our knowledge, and for a general representation of the earth's figure, there is really nothing gained by departing from Bessel's spheroid, viz: Radius, geocentric, major, 6,377,397 meters, or 20,923,597 feet; radius, geocentric, minor, 6,356,079 meters, or 20,853,654 feet; radius, geocentric, at 45° latitude, 6,366,787; radius of a sphere of equivalent surface, 6,370,191. The latter is the radius most generally appropriate for computing or charting meteorological data. The length of the quadrant from the pole to the equator of Bessel's spheroid is 10,000,856 meters. The probable uncertainty still attaching to the above values of the major and minor radii is about 500 meters, or $\frac{1}{13000}$ part of the whole.

The radii adopted in the geodetic section of the International Meteorological Tables are those of Bessel's spheroid, as above, but the approximate value, 6,370,000 meters, is adopted on page A 13 for the computation of gravity, and the value, 6,371,104, on page A 37, in the computation of the barometric constant, and the same value is again introduced, on pages A 40, A 41, A 45, in the computation of the gravity term of the barometric formula; these slight variations are often unimportant, but the larger value, 1.0026215 × 6,370,191 = 6,386,891, is preferable, as shown by the preceding computation.

NECROLOGY.

The following, by Mariano Bárcena, Director of the Central Meteorological Observatory, is quoted from the *Boletin Mensual* for November, 1896:

On the 28th of last October Don Miguel Perez, Engineer and Subdirector of the Central Meteorological Observatory, died in the city of Coyoacan, the victim of a painful malady caused by his devotion to study and his assiduity in the performance of his duties.

Senor Perez was born in the city of Mexico on the 28th of September, 1847. His studies of civil engineering and architecture were made in the Academy of San Carlos and in the School of Engineering of Mexico. He was always distinguished for his brilliant progress, and obtained various prizes in his studies. He was one of the founders of the Central Meteorological Observatory, in the year 1877, and occupied the position of second observer, and a short time after that of subdirector of this institution, the duties of which he always discharged with the greatest ability. In addition to these he made numerous and very important physical and meteorological studies. He was professor in the Academy of Fine Arts in Mexico, and also in the engineering and military schools, where he occupied the chairs of Calculus of Probabilities and Cosmography. In the National Preparatory School he served for a long time as master of the preparatory classes of physics. He was a member of the Mexican societies of natural history, mining, geography, and statistics; the scientific society, Antonio Alzate; honorary member of medical fraternity of Guadalajara and of that of the engineers of Jalisco; Fellow by Merit of the Iberian-American Union of Madrid; corresponding member of the Scientific Association of Brussels and of the Royal Academy of Exact Sciences, Physical and Natural of Madrid; regular member and pro-secretary of the Academy of Mexico and correspondent of the Royal Spanish Academy.

Besides the observations and compilations made by Senor Perez during his long employment at the Observatory, he wrote numerous memoirs and assisted in many special works such as: Annuals of national and international comparative meteorology; Annual Meteorological Charts; Barometric Tables; Bulletin of the Central Meteorological Observatory; Mexican Carpology and many other publications. He was one of the editors of several scientific periodicals, such as: The Industrial Promoter; The Mexican Miner; The Bulletin of the Ministry of the Interior and was one of the group of founders and editors of the Scientific Mexican Review.

Mexican science has lost in Senor Perez one of its most distinguished and intelligent votaries and the personnel of the Central Meteorological Observatory mourns the early death of one of its most industrious and intelligent colleagues and an excellent friend.

The death of Senor Perez has also called forth from Senor Ángel Anguiano, the Director of the National Astronomical Observatory at Tacubaya, an eloquent tribute, signed by his first assistant, Senor Felipe Valle, which we reproduce from the *Anuario*, in memory of this distinguished Mexican meteorologist and engineer:

On October 28, 1896, the Central Meteorological Observatory of Mexico sustained a great loss by the death of its Subdirector, Don Miguel Perez, Engineer, who ever since the establishment of this institution has devoted his brilliant intellect and his indomitable perseverance to the development and advancement of meteorology in Mexico.

The works that he has produced are his best eulogy, and they bear testimony to his intelligent labor during the four lustrums consecrated by him to the study of meteorology. All that we might say in his praise would be feeble in consideration of his eminent merits.

He was distinguished not only as meteorologist but as a professor in the military and engineering schools, where he was a model in his conscientious fulfillment of the duties imposed upon him by his superiors.

As sincere friends of the lamented engineer, whose painful loss we greatly deplore, intimately acquainted with his scientific acquirements and his private virtues, with his noble enthusiasm for all that could benefit the country, and recognizing his skill as an assistant in many undertakings accomplished by this observatory, we, of the Astronomical Observatory, with our whole hearts join in the grief of the Meteorological Observatory and announce to the readers of our *Annuaire* the irreparable loss which science in Mexico has sustained by his death.

Messrs. Rafael J. Sanchez and Ricardo Adan Funes, assistants at the Meteorological and Astronomical Observatory of San Salvador, under date of October 31, 1896, announce:

On the 25th of this present month there died in this city, the worthy director of the Observatory and distinguished mathematician, Doctor Alberto Sanchez.

Society in general deeply mourns this irreparable loss, but it is felt more particularly by this Institution which owes to the indefatigable Dr. Sanchez the state of progress which it has attained under his administration.

The following is quoted from an announcement of November 10 by Julian Aparicio, Director of the Meteorological and Astronomical Observatory of San Salvador:

I have the honor to inform you that on the 3d of the current month I was appointed director of the National Observatory in consequence of the irreparable loss we have sustained in the death of the illustrious mathematician, Doctor Don Alberto Sanchez.

METEOROLOGICAL TABLES.

By A. J. HENRY, Chief of Division of Records and Meteorological Data.

Table I gives, for about 130 Weather Bureau stations making two observations daily and for about 20 others making only the 8 p. m. observation, the data ordinarily needed for climatological studies, viz, the monthly mean pressure, the monthly means and extremes of temperature, the average conditions as to moisture, cloudiness, movement of the wind, and the departures from normals in the case of pressure, temperature, and precipitation.

Table II gives, for about 2,400 stations occupied by voluntary observers, the extreme maximum and minimum temperatures, the mean temperature deduced from the average of all the daily maxima and minima, or other readings, as indicated by the numeral following the name of the station; the total monthly precipitation, and the total depth in inches of any snow that may have fallen. When the spaces in the snow column are left blank it indicates that no snow has fallen, but when it is possible that there may have been snow of which no record has been made, that fact is indicated by leaders, thus (. . . .).

Table III gives, for about 30 Canadian stations, the mean pressure, mean temperature, total precipitation, prevailing wind, and the respective departures from normal values.